I 1008

Attachment H

COVER SHEET (PAGE 1 of 2)

May 1998 CALFED ECOSYSTEM RESTORATION PROPOSAL SOLICITATION

Proposal Title: Evaluation of the effectiveness of screens for fish protection at small diversions

Applicant Name: Joseph J. Cech, Jr.
Mailing Address: Dept. Wildlife, Fish, and Conservation Biology
University of California, Davis, CA 95616
Telephone: (530)752-3103
Fax: (530) 752-4154

Amount of funding requested: $ 199,896 for 1.25 years

Indicate the Topic for which you are applying (check only one box). Note that this is an important decision: **see page __ of the** Proposal Solicitation Package for more information.

- ☐ **Fish Passage Assessment**
- ☐ Fish Passage Improvements
- ☐ **Floodplain and Habitat Restoration**
- ☐ Gravel Restoration
- ☐ **Fish Harvest**
- ☐ Species Life History Studies
- ☐ **Watershed Planning/Implementation**
- ☐ Education
- ☒ **Fish Screen Evaluations - *Alternatives and Biological Priorities***

Indicate the geographic area of your proposal (check only one box):

- ☐ Sacramento River Mainstem
- ☐ Sacramento Tributary: _____
- ☒ Delta
- ☐ East Side Delta Tributary: _____
- ☐ Suisun Marsh and Bay
- ☐ San Joaquin Tributary: _____
- ☐ San Joaquin River Mainstem
- ☐ Other: _____
- ☐ Landscape (entire Bay-Delta watershed)
- ☐ North Bay: _____

Indicate the primary species which the proposal addresses (check no more than two boxes):

- ☐ San Joaquin and East-side Delta tributaries fall-run chinook salmon
- ☐ Winter-run chinook salmon
- ☐ *Spring-run chinook salmon*
- ☒ Late-fall run chinook salmon
- ☐ Fall-run chinook salmon
- ☒ Delta smelt
- ☐ Longfin smelt
- ☐ Splittail
- ☐ Steelhead trout
- ☐ Green sturgeon
- ☐ Striped bass
- ☐ Migratory birds

COVER SHEET (PAGE 2 of 2)

May 1998 CALFED ECOSYSTEM RESTORATION PROPOSAL SOLICITATION

Indicate the type of applicant (check only one box):

☐	State agency	☐	Federal agency
☐	Public/Non-profit joint venture	☐	Non-profit
☐	Local government/district	☐	Private party
☒	University	☐	Other: _____

Indicate the type of project (check only one box):

☐	Planning	☐	Implementation
☐	Monitoring	☐	Education
☒	Research		

By signing below, the applicant declares the following:

(1) the truthfulness of all representations in their proposal;

(2) the individual signing the form is entitled to submit the application on behalf of the applicant (if applicant is an entity or organization); and

(3) the person submitting the application has read and understood the conflict of interest and confidentiality discussion in the PSP (Section II.K) and waives any and all rights to privacy and confidentiality of the proposal on behalf of the applicant, to the extent as provided in the Section.

Joseph C. Sachs Jr.

(Signature of Applicant)

Proposal to:

Name CALFED Bay-Delta Program Office
Address 1416 Ninth Street, Suite 1155
Sacramento, CA 95814

Submitting Organization:

The Regents of the University of California
University of California
Davis, California 95616

Title of Proposed Research:

Evaluation of the effectiveness of screens for fish protection at small diversions

Total Amount Requested:	Proposed Duration:	Desired Starting Date:
$199,896	1.25 years (15 months)	December 1998

Principal Investigator/ Co-Principal Investigator(s):	Department:	Phone Number:
Joseph J. Cech, Jr.	Wildlife, Fish, and Conservation Biology	(530) 752-8659

Checks Made Payable to:

The Regents of the University of California

Send Checks to:

Cashier's Office
University of California
Davis, CA 95616

Send Award Notice to:

Office of Research
University of California
Davis, California 95616
(916) 752-2075

Approvals:

Joseph J. Cech Jr. 6-18-98
Principal Investigator Date

Co-Principal Investigator Date

Co-Principal Investigator Date

18 Jun 98
Department Chair Date

Dean, College/School Date

Sandra M. Dorsey JUN 29 1998
Official Signing for Organization

NK:br/05-11-94/proposal.frm

I-012826

I. EXECUTIVE SUMMARY

A. Project Title and Applicant Name

EVALUATION OF THE EFFECTIVENESS OF SCREENS FOR FISH PROTECTION AT SMALL DIVERSIONS; Dr. Joseph J. Cech, Jr. UC Davis

B. Project Description and Primary Biological/Ecological Objectives

The objective of this project is to evaluate the effectiveness of small diversion fish screens for fish exclusion and fish protection. This project addresses a major environmental stressor identified by CALFED, alteration of flows and effects of water management activities, and associated entrainment and impingement mortality of priority fish species. The project is specifically designed to quantitatively evaluate the effectiveness of one of CALFED's primary mitigation strategies, installation of fish screens, for fish protection. Specific questions addressed include:

Do fish screens exclude fish?
Are excluded fish harmed or killed by exposure and possible impingement on the screen?
Do these responses differ among several priority species?
Do these responses differ between day and night diversion operation?

Answers to these questions will assist environmental managers and water users to make decisions regarding screening of small water diversions and to apply adaptive management techniques in water diversion operation which protect fish and enhance ecosystem quality.

C. Approach/Tasks/Schedule

The approach of this project is to quantitatively evaluate the survival and behavioral responses of several small-size priority fish species (chinook salmon parr and smolts, delta smelt, juvenile splittail) exposed to an unscreened and screened water diversion under controlled environmental conditions in a large, laboratory-based flume (Agricultural Diversion Apparatus, ADA, Figure 1). Three screen treatments (unscreened 10 inch diameter pipe, and a commercially available cylindrical fish screen with regulation mesh size, operated at 0.2 and 0.33 fps approach velocity) will be tested during the day (light conditions) and night (dark conditions). The cylindrical screen used in this project will be identical (although smaller in size) to that currently used in an IEP field project evaluating the effectiveness of this type of screen for fish exclusion at an agricultural diversion on Sherman Island in the Delta. Measurements will include fish behavior (e.g., swimming velocity, distance from screen surface), entrainment, impingement, physical injury, and survival.

The 15 month project is scheduled in three phases. Phase 1 (4 months) will include final design, construction, and testing of the ADA and preparation of a Quality Assurance Project Plan for biological tests using the ADA. Biological tests will be conducted during Phase 2 (8 months). Final data analyses and interpretation, including comparison of laboratory results with complementary field data and other ongoing fish screen studies (e.g., Fish Treadmill project, DWR contract #B-80898), and report writing will be completed during Phase 3 (3 months).

D. Justification for Project and Funding by CALFED

Installation of fish screens at small water diversions has been identified by CALFED as an activity which provides direct benefit to fish resources and the ecosystem. However, except for some limited evidence that fish screens exclude fishes >5 mm in length, there is no information on whether excluded fishes are harmed or killed by exposure to artificial flow regimes and/or impingement on the screen. Therefore, the effectiveness of fish screens for fish protection is unknown and unproven. The proposed project will quantitatively evaluate the effectiveness of small diversion fish screens for both fish exclusion and fish

protection, with an emphasis on small-size, priority species which may be at greater risk from these installations.

This project should be funded under the CALFED program for several reasons. It addresses questions and will produce information applicable to mitigate problems in the Sacramento-San Joaquin Delta and river system associated with alteration of flows, effects of water management activities, and entrainment and impingement mortality of priority fish species, key high rank stressors identified by CALFED. It specifically addresses one of the nine topics identified by CALFED as a priority problem in the Bay-Delta ecosystem, evaluating fish screens at small water diversions, and has direct relevance to at least one other topic, fish passage and related screen improvements. It focuses on priority species that are documented to be at high risk from the stressor. Understanding of the effects of installation of fish screens, beyond the issue of fish exclusion to that of fish protection, is essential to the CALFED mission of ecosystem restoration, enhancing fish populations (including fish doubling goals mandated by the CVPIA), providing information and tools for effective adaptive management by agencies and water users, and maintaining water use by small diverters throughout the system.

E. Budget Costs and Third Party Impacts

Total funding requested from CALFED is $199,896 for 15 months. This amount includes funds for equipment, supplies, and labor for construction of the ADA, salaries and benefits of personnel (post-graduate research biologists and student research assistants), travel, publication costs, and overhead. Additional support will be provided by our funding partners, including UC Davis, DWR, DFG, and fish screen and pump manufacturers. Potential third party impacts resulting from this project include enhanced sport, commercial, and native Californian fisheries resulting from improved fish populations, and the improved ability of small water users to operate diversions in ways which better protect Delta and riverine fishes.

F. Applicant Qualifications

Dr. Joseph J. Cech, Jr., is a professor at the University of California, Davis, and a well recognized authority on physiology and behavior of fishes. He has successfully completed seven state agency contracts, many with an emphasis on Delta and riverine fishes. He is currently co-principal investigator, with Dr. M. L. Kavvas, a hydraulic engineer, on a study of the performance and behavior of Delta fishes exposed to large flat plate fish screens.

G. Monitoring and Data Evaluation

Data collection and evaluation will be thoroughly described in a Quality Assurance Project Plan prepared by the principal investigator and research staff and reviewed and approved by experts from collaborating agencies. In addition to quarterly, annual and final reports, results will be presented at interagency workgroup meetings, workshops, and professional scientific meetings, and published in peer-reviewed journals.

H. Local Support/Coordination with Other Programs/Compatibility with CALFED Objectives

Most of the infrastructure and capitol equipment required for this project is already available at the UCD Aquatic Center and UCD Fish Environmental Biology Laboratory. Extensive cooperative and collaborative research and funding arrangements between the applicant, other UCD researchers, state agencies (e.g., DWR, DFG), and fish screen and pump manufacturers are in place or pending. This project complements several ongoing field and laboratory based projects investigating fish responses to fish screens, fish screen effectiveness, and fish screen hydraulic performance.

II. TITLE PAGE

Title of project: **EVALUATION OF THE EFFECTIVENESS OF SCREENS FOR FISH PROTECTION AT SMALL DIVERSIONS**

Principle Investigator: Joseph J. Cech, Jr., Professor
Department of Wildlife, Fish, and Conservation Biology
University of California, Davis, CA 95616
(916) 752-3103, FAX (916) 752-4154, jjcech@ucdavis.edu

Type of Organization and Tax Status: State assisted public research and educational institution

Tax Identification Number: 94-603-6494

Technical and Financial Contact Persons:

Technical: Joseph J. Cech, Jr., Professor
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(916) 752-3103, FAX (916) 752-4154, jjcech@ucdavis.edu
Financial: Ms. Marjorie Kirkman
Department of Wildlife, Fish, and Conservation Biology
University of California, Davis, CA 95616
(916) 752-6584, FAX (916) 752-4154, makirkman@ucdavis.edu

Participants and Collaborators in Implementation:

California Department of Fish and Game
California Department of Water Resources
U. S. Filter/Johnson Screens (pending)
Cornell Pump Co. (pending)

III. PROJECT DESCRIPTION

A. Project Description and Approach

1. *Introduction*

Water diversions in the Sacramento-San Joaquin Delta and river system have serious deleterious effects on many resident and transient fishes. Most management concerns and research efforts have focused on large diversions (e.g., state and federal pumping facilities, and industrial and urban water diversions). However, the majority of the water diversions located throughout the system are small (<25 cfs), unscreened agricultural diversions that, combined, divert as much water as that exported by the state and federal pumping facilities in the south Delta. Fish entrainment losses have been quantified at a limited number of agricultural diversions in the Delta and there is some evidence that installation of fish screens effectively excludes fishes larger than 5 mm total length (IEP, Technical Report 37, 1994). However, there is no information on whether larger fishes are entrained and impinged at these screened diversions and whether such exposure is harmful. Does exclusion protect fish? Can entrained fish escape or do they impinge on the fish screen? Does the ability of the fish to escape entrainment and impingement differ during the day and night? Is impingement stressful or lethal? Do the effects of entrainment and impingement differ among species? For Delta fishes these questions have not been answered. Therefore, the effectiveness of past and present screening efforts throughout the system, including those implemented under the CALFED program, for protecting these aquatic resources and improving ecosystem quality is unknown.

We propose to quantitatively evaluate the effects of exposure to screened and unscreened agricultural-type water diversions on several priority Delta fish species using a large laboratory-based flume equipped with a 10 inch diameter diversion pipe and cylindrical fish screen. This will be the first biological evaluation of the effectiveness of small fish screens for Delta fish protection rather than simply fish exclusion. Our results will assist environmental and resource managers to make decisions regarding screening of small water diversions in ways which truly protect fish, enhance ecosystem quality, and contribute to fish doubling goals mandated by the CVPIA. In addition, this project complements at least two other ongoing projects to evaluate fish screen effectiveness, an IEP field research and monitoring project to evaluate the effectiveness of a fish screen at an agricultural diversion in the Delta (Sherman Island) and a laboratory-based evaluation of the behavior and performance of Delta fishes exposed to large flat-plate fish screens (Fish Treadmill project, DWR contract #B-80898).

2. Objective

The objective of the project is to evaluate and quantify the survival and behavior of several priority Delta fishes exposed to an unscreened and screened small water diversion during the day and night.

3. Methods

Experiments will be conducted using a large scale, laboratory-based flume equipped with a pipe diversion that can be fitted with a cylindrical fish screen. The apparatus is designed to provide controlled flow and environmental conditions, and a fish screen installation similar to those used at some agricultural diversions in the Delta, and identical (although smaller in size) to that used in the ongoing field evaluation of an agricultural diversion on Sherman Island in the Delta. This approach will enable us to test fishes in clear water conditions, to quantitatively observe and track their movements and responses to the diversion and screen, and to assess any lethal and sublethal effects of exposure and impingement. Specific aspects of the experimental design and ranges of variables are outlined below.

Agricultural Diversion Apparatus: The agricultural diversion apparatus (ADA, Figure 1) will consist of a large flume fitted with a 10-inch diversion pipe inserted through the wall. The diversion pipe can be fitted with a fixed cylindrical fish screen equipped with an air burst cleaning system. During operation, water diverted through the experimental diversion (pump capacity 3-6 cfs) will pass through a fish collection tank equipped with a lift net before returning to the ADA tank. Low velocity lateral flows (<0.2 fps or 6 cm/s) within the experimental flume section will be generated by the ADA recirculating pump and straightened using vanes and baffles upstream of the experimental section. The ADA will operate using a flow-through water supply (>30 gal/min) to maintain high water quality and relatively constant temperature. Fish will be confined in an area around the diversion pipe using rigid plastic mesh partitions (confinement area dimensions: 4 ft long, 4 ft wide, 4 ft deep). For each experimental flow treatment (see below) and fish screen treatment, water velocities at specific locations in the area around the diversion will be measured using a three-dimensional Acoustic-Doppler flow meter.

Species: While a number of small-size Delta and riverine fishes are thought to be adversely affected by agricultural diversions, priority for these experiments will be:

1) chinook salmon parr and smolts.
2) delta smelt.
3) splittail young-of-the-year.

Other species (e.g., steelhead) may be tested if adequate numbers of fish are available and/or field data from cooperating agencies suggest these fish are at greater risk from small water diversions.

Fish Screens and Approach Flow Velocity: Three water diversion screening strategies will be tested.

1) No fish screen, approach velocity flow at pipe 2-4 fps (estimated).
2) Fixed cylindrical screen with air burst cleaning system (e.g., Johnson Intake Screen, single drum) operated at 0.2 fps (6 cm/s) approach flow velocity.
3) Fixed cylindrical screen with air burst cleaning system operated at 0.33 fps (10 cm/s) approach flow velocity.

Control experiments will be conducted using no flow (0 fps) through the screened and unscreened diversion treatments.

Environmental Conditions: Experiments will be conducted during the late winter, spring, and fall at one temperatures, 18.5±1.0°C (ambient well water temperature at the UCD Aquatic Facility) during the day (2 h after sunrise to 2 h before sunset) under shaded daylight conditions and during the night (2 h after sunset) under dark conditions.

Measurements: For each experiment, two types of measurements will be made. Fish behavior and their responses to the water diversion and fish screen will be measured during the experimental exposure period. The physiological effects of exposure to the diversion will be measured at selected times after the end of the experimental exposure period.

Fish behavior and responses to the diversion will be monitored during each experiment visually by researchers as well as recorded by two 60 frame/s video cameras mounted in stationary locations. One camera will be suspended above the apparatus to view the diversion and fish from above, the other will be positioned to view the fish directly in front of and beside (upstream or downstream) the diversion. Nighttime visual observations will be conducted using infra-red sensitive night vision goggles and

nighttime video recording will use a video camera equipped with an infra-red sensitive night vision scope. Recordings from each camera will be analyzed using a computer-assisted motion analysis system (Peak Performance Technologies, Inc., Engelwood, CO). For each video record, information on flow velocities and directions, fish size, and linear scaling will be incorporated into the computer program and/or data record for calibration purposes. Measurements will include fish orientation, location within the apparatus (e.g., distance from screen surface), swimming velocity, distance and direction traveled, loss of equilibrium, and impingement on screen. Fish orientation, and distance, direction and velocity traveled over the ground will be combined with velocity-vector maps of the ADA to calculate true swimming velocities and distance traveled through the water by individual fish. Physiological responses will be evaluated using two standards of performance, mortality and sublethal physical damage (e.g., damage to skin, scales, fins and eyes). Survival will be monitored during all experiments and for a minimum of 48 h post-test in fresh water.

Experimental Protocol: Each experiment will consist of an initial pre-test, habituation period during which approach flow = 0 fps and lateral flow = 0-0.2 fps (0-6 cm s^{-1}), a test period during which the water will flow through the diversion at the prescribed rate, and a post-test period during which water flow through the diversion is suspended. Our preliminary plans call for 1 h, 0.25-2 h, and 1 h for the pre-test, test, and post-test periods, respectively, but these durations may be modified depending on results of pilot studies. For each experiment, 20-40 fish will be used (final group size for each species to be determined by pilot studies).

B. Proposed Scope of Work

The proposed project consists of three phases. Phase 1 (duration: 4 months) includes final design modifications, acquisition of materials, construction of the ADA, pilot studies to finalize experimental protocols, development of detailed flow profiles for each of the fish screen and flow velocity treatments, and preparation and approval of a Quality Assurance Project Plan. During Phase 2 (duration: 8 months) we will conduct replicated experiments with each of the species and treatments outlined (probable order of species tests based on predicted availability: chinook salmon, splittail, and delta smelt). Final data analyses and interpretation, including comparisons of results with complementary data from other ongoing field and laboratory fish screen studies and report writing will be completed during Phase 3 (3 months).

C. Location and/or Geographic Boundaries of the Project

The stressors, habitats, and species addressed by this project are located in all areas within the Sacramento-San Joaquin Delta and river system that are affected by small unscreened and screened water diversions. The quantitative data generated by this laboratory-based project will be immediately applicable and complementary to an ongoing field evaluation of screened and unscreened agricultural diversions at Sherman Island (located in the Sacramento-San Joaquin Delta). In addition, results of the project will be broadly applicable to IEP agency and CALFED decision makers to assess and predict the beneficial effects of screening small diversions throughout the Delta and tributary rivers.

D. Expected Benefits

This project addresses problems in the Sacramento-San Joaquin Delta and tributary rivers associated with alteration of flows, effects of water management activities, and entrainment and impingement losses of fishes at screened ad unscreened water diversions. The project is designed to identify, evaluate, and

quantify the benefits and, possibly, the limitations of installation of fish screens at small water diversions, a restoration activity whose value for protecting fishes and improving ecosystem quality is not yet documented. The results will have application and provide benefit to several habitat types, including tidal perennial aquatic habitat, instream aquatic habitat, and shaded riverine habitat, and all fishes which reside in or pass through these habitats. This project will specifically evaluate the effects of small diversions and fish screens on several priority fish species, chinook salmon, delta smelt, and splittail, thought to be a high risk from these stressors. Results may be applicable to predict diversion and screen impacts on other ecologically and/or morphologically similar species not tested (e.g., steelhead, longfin smelt, striped bass).

Expanding our understanding of the effects of installation of fish screens beyond the issue of fish exclusion to that of fish protection is essential to the CALFED mission of ecosystem restoration and enhancing fisheries resources while maintaining water use by small diverters throughout the system. Further, understanding of the possible differential performance of different species under different environmental conditions (e.g., day vs night) will assist environmental managers and water diverters to apply adaptive management techniques to maximize water usage while minimizing deleterious effects on fishes in the Delta and river systems. Finally, this apparatus, once developed, will also be useful for studies on the effects of other environmental and biological conditions (e.g., temperature, turbidity, salinity, fish size, other species), screen types (e.g., conical screens, rotating cylindrical screens), diversion orientation or configuration, and pump types (e.g., "fish friendly" pumps) on fish survival and behavior.

E. Background and Biological/Technical Justification

Installation of fish screens at unscreened water diversions throughout the Sacramento-San Joaquin Delta and river system has been identified by CALFED as an activity which provides a direct benefit to fish resources and the ecosystem. However, the only benefit of fish screen installation documented to date is the exclusion of fishes >5 mm in length. It is not known whether excluded fishes are harmed or killed by exposure to artificial water flows at the diversions (i.e., entrainment) or impingement on the fish screens. The direct benefit attributed to screen installation is unproven.

The proposed project will quantitatively evaluate the effectiveness of small diversion fish screens for both fish exclusion and fish protection. It addresses a specific ERPP objective, reduction of fish entrainment at water diversions to increase survival and population abundances to levels that contribute to the overall health of the Delta and reduce conflicts with other beneficial uses (Volume 1, Water Diversions, Small unscreened diversions, pp. 274-277). In addition, through its focus on chinook salmon (project results should be applicable to all runs), this project also addresses objectives of the Anadromous Fish Restoration Program and other sections of the CVPIA. Our results will provide environmental managers and water users with information essential to make decisions regarding screening and operation of small water diversions that, by protecting fishes, enhance ecosystem functioning and quality.

This experimental approach and use of a laboratory-based system for a biological evaluation of the fish protection qualities of fish screens is preferable to field studies and will provide greater direct benefit than either field studies or detailed hydraulic evaluations of various screen types for several reasons.

1) Observations of fishes near fish screens installed at water diversions in the Delta or rivers are logistically and technically difficult (e.g., turbid water conditions limit visibility for human or video observations).

2) The presence, numbers, species, and sizes of fishes near any particular diversion are not predictable and cannot be replicated, therefore development of a scientifically and statistically valid study to assess screen effectiveness is difficult. Artificial introduction of test fish near the diversion and screen is problematic because the effects of exposure to the diversion cannot be easily separated from the stressful effects of handling and release, and these stressed fish may respond differently to the diversion than unhandled fish.

3) Long-term effects of exposure and impingement (e.g., survival) on field-exposed fishes cannot be evaluated (e.g., the effects of post-exposure collection and handling are difficult to distinguish from screen exposure and impingement effects).

4) Environmental conditions (e.g., temperature, lateral flow rates, light levels) are inherently uncontrolled and cannot be replicated or tested quantitatively.

5) Swimming performance and behavior studies using flumes, flow tables, and large tanks with many fishes, including priority Delta species, have consistently shown that fishes respond to many stimuli, not just flow velocity and direction, and that their responses vary with environmental conditions (e.g., day vs night). Therefore, while detailed descriptions of flow regimes at fish screens are helpful, they can not be used to predict fish responses or movement patterns near these structures.

While the proposed project is new, it continues the applied research interest and collaborative activities of our laboratory on the effects of flows, fish screens, and environmental conditions on the performance, behavior, and physiology of Delta fishes. Much of the required laboratory, fish holding, and hydraulic facilities and infrastructure are in place and available (see G. Implementability, Available Facilities). This project capitalizes on a number of existing and new cooperative and collaborative arrangements between our applied environmental biology research group, state and federal resource agencies (e.g., DWR, DFG, USFWS), and several commercial enterprises (e.g., U. S. Filter/Johnson Screens). It also complements several ongoing and proposed projects, including the Fish Treadmill project (DWR contract # B-80898) and a field-based investigation of fish exclusion at screened and unscreened agricultural diversions on Sherman Island in the Delta.

F. Monitoring and Data Evaluation

Data collection, acceptability, quality control, and evaluation will be described thoroughly in a Quality Assurance Project Plan prepared by the Principal Investigator and research staff (including research collaborators from state and federal agencies) and reviewed and approved by one or more experts from these collaborating agencies who are not directly involved in the project. In addition to quarterly, annual and final reports, results will be presented at interagency workgroup meetings and workshops, professional scientific meetings, and published in peer-reviewed scientific journals in the appropriate fields.

G. Implementability

The proposed project is highly implementable. It utilizes existing facilities and resources at the University of California, Davis, ongoing and productive collaborative and cooperative arrangements with a number of state and federal resources agencies, and fosters further development of working relationships between these entities and several commercial enterprises (e.g., fish screen producers). It capitalizes on a unique combination of available, functional laboratories and expertise in fish biology (including Delta fishes), hydraulics, and fish screen technology and operation (see V. Applicant Qualifications). There are no laws, regulations, land use conditions, hazardous materials concerns, etc. which would delay or preclude implementation of this project.

Available Facilities: Most of the substantial infrastructure and capital equipment required for the project is already in place and available. The project will be implemented at the UCD Aquatic Center where the ADA will be constructed and installed and where the experimental fishes will be maintained, and UCD Fish Environmental Physiology Laboratory where behavioral and physiological data and samples will be analyzed. Aquatic Center facilities include: a dedicated well which provides non-chlorinated, air-equilibrated water; a large scale, temperature-controlled fish holding facility (e.g., 23 tanks are available for this project); and an experienced staff for fish care and technical support. The Fish Environmental Biology Laboratory facilities include: computer-assisted motion analysis system; video and night vision equipment; and computers with necessary database access and software.

Permits: Required permits for animal collection and care, and water use and discharge are on file or currently being processed.

Cooperative arrangements: Ongoing and planned cooperative arrangements between the Fish Environmental Biology Group (Department of Wildlife, Fish, and Conservation Biology) and other University, state agency, and commercial entities are listed below.
UCD Fish Pathology Laboratory (School of Veterinary Medicine): Fish disease diagnosis and treatment.
DWR: Assist in design, construction, testing, and use of the ADA for experiments.
DFG: Assist in fish collection and experiments
U. S. Filter/Johnson Screen (pending): Provide cylindrical fish screen.
Cornell Pump Co. (pending): Provide "fish friendly" pump for ADA pipe diversion.

IV. COSTS AND SCHEDULE TO IMPLEMENT PROPOSED PROJECT

A. Budget Costs

Total funding requested from CALFED is $199,896 for 15 months (see Table 1). Budget costs for Phase 1 include: salaries and benefits of post-graduate researchers who will finalize the ADA design, construct and test the apparatus, develop and test experimental protocols, prepare the Quality Assurance Project plan, and collect fish for use in the experiments; ADA equipment; travel for acquisition of construction materials and supplies and preliminary fish collection; UCD Aquatic Center fees; and overhead. The budget costs for the ADA are for components of the apparatus, including the flume tank, fish collection tank, pumps, butterfly valves, and a pole-barn type roof over the apparatus, and equipment for visual and video observation and analyses, including night vision equipment and video cameras. Construction and/or installation of this apparatus at a facility without the water handling and fish holding infrastructure available at the UCD Aquatic Center would be more expensive. Budget costs for Phase 2 are for: salaries and benefits for research staff; supplies; travel; UCD Aquatic Center fees; and overhead. Students will be employed on an hourly basis, but implementation of the project requires salaried personnel for assembly, operation, and maintenance of the ADA, fish collection, care, experimental set-up, data collection and analysis. Budget costs for Phase 3 are for: salaries and benefits of senior post-graduate researchers who will complete the data analyses and interpretation, and prepare final reports and journal articles; and overhead

Funding Partners: Extensive cooperation and collaboration with engineers and biologists from DWR and DFG are anticipated (see Table 2 for support, including in kind, from funding partners). DWR will provide the part-time services of a hydraulic engineer for consultation and assistance during the design, construction and testing of the ADA, and a biologist to assist with the preparation of the QAPP and the design, implementation, and analyses of experiments using the ADA. DFG will provide part-time services of personnel and equipment to assist in fish collection, and of a biologist to assist with the preparation of the QAPP and the design, implementation, and analyses of experiments using the ADA. Negotiations with U. S. Filter/Johnson Screens (Castro Valley, CA) to provide a small cylindrical fish screen for use in the ADA, and with Cornell Pump Co. (Portland, OR) for use a "fish friendly" pump, are ongoing.

Potential for Incremental Funding: Because the proposed project requires a moderately large capital outlay for construction of the ADA before experiments can be initiated, and involves relatively long-duration and complex biological tests on live fishes which may only be available seasonally, the potential for incremental funding is limited. Biological experiments, particularly those designed to test several variables (e.g., fish species, day vs night), require replication in order to produce scientifically and statistically valid results and are time consuming. Further, a commitment for the entire 15 months will facilitate attracting and keeping top-quality post-graduate researchers and maintaining a smoothly running program.

Table 1. Cost breakdown of funding requested from the CALFED Program.

	Phase 1 (4 months)	Phase 2 (8 months)	Phase 3 (3 months)
Salary and benefits	32,419	64,838	12,375
ADA equipment	39,700	0	0
Miscellaneous supplies for construction , office, and experiments	12,000	10,000	0
Other direct costs (water fees, travel, publication, etc.)	3,000	7,000	4,000
Overhead (10% of direct cost excluding equipment)	4,742	8,184	1,638
TOTAL	91,861	90,022	18,013

GRAND TOTAL (15 months) = $199,896

Table 2. Total funding for the project including counterparts from funding partners.

	Phase 1	Phase 2	Phase 3	Total
UC Davis	4019 [a]	8039 [a]	3015 [a]	15,073
DWR	2,000 [b]	2,000 [b]	0	4,000
DFG	1,000 [c]	10,000 [c]	0	11,000
Screen/pump co.	6,000 [d]	0	0	6,000
CALFED	91,861	90,022	18,013	199,896
TOTAL	104,880	110,115	21,028	235,969

Legends:
[a] salary and benefits for J.J. Cech (5%)
[b] estimated salaries of DWR personnel
[c] estimated salaries and equipment for fish collection from DFG.
[d] fish screen and pump donation

B. Schedule Milestones

Phase 1	
December 1998	Funding begins;
December 1998 - March 1999	Final design modifications, acquisition of materials, and construction and testing of the ADA. Develop flow profiles for unscreened and fixed cylindrical screens. Conduct pilot studies to finalize experimental protocols. Prepare Quality Assurance Project Plan.
February 1999	Collect chinook salmon parr from DFG hatcheries.
April 1999	Submit final report for Phase 1
Phase 2	
April-November 1999	Conduct replicated experiments with chinook salmon (late winter-spring), splittail (spring-summer), delta smelt, (summer-fall). Fish collection as necessary.
June 1999	Submit quarterly report.
October 1999	Submit quarterly report.
Phase 3	
December 1999 - February 2000	Final analyses and interpretation of data, prepare final report, journal articles.
March 2000	Submit Final report, submit journal articles for publication.

C. Third Party Impacts

Application of the results of this proposed project could have impacts on sport, commercial and native Californian fisheries by improving protection of fishes at small water diversions throughout the Delta and river system and thus enhancing fish populations. Results could also have impacts on small water diverters by suggesting improved designs and operational guidelines for diversions and fish screens which better protect Delta and riverine fishes.

V. APPLICANT QUALIFICATIONS

A. Organization of Staff

The project will be under the direction and supervision of the principal investigator, Dr. J. J. Cech, Jr., Professor in the Department of Wildlife, Fish, and Conservation Biology, University of California, Davis. Day to day project management, implementation, data analysis, interpretation, and report writing will be provided by two post-graduate researchers, Drs. C. Swanson and P. S. Young. Part-time post-graduate researchers will assist with ADA construction, operation, fish collection and care, and data collection and analysis. Collaborating engineers and biologists from DWR and DFG will work with the principal investigator and managing biologists.

B. Collaborating Scientists

Dr. Joseph J. Cech, Jr. has been a professor at UCD since 1975 and was Chair of the Department of Wildlife, Fish, and Conservation Biology from 1992-1997. He has published more than 80 peer-reviewed articles and books in the fields of physiology and physiological ecology of fishes, and has won numerous awards, honors, and grants. He has successfully completed seven contracts with state agencies for studies of the physiological ecology of fishes in the Sacramento-San Joaquin Delta and rivers. He is currently co-principal investigator, with M. L. Kavvas, Department of Civil and Environmental Engineering, UCD, on the Fish Treadmill Project (DWR contract # B-80898), a comprehensive study of the performance and behavior of Delta fishes exposed to three-dimensional flow fields and large flat-plate fish screens. Recent relevant publications include:

Cech, J. J., Jr., Mitchell, S. J. Castleberry, D. T., and McEnroe, M. (1990) Distribution of California stream fishes: influence of environmental temperature and hypoxia. Env. Biol. Fish. 29:95-105.

Moyle, P. B. and Cech, J. J., Jr. (1996) Fishes: an introduction to ichthyology. 3rd edition, Prentice Hall, Englewood Cliffs, New Jersey.

Cech, J. J., Jr., Bartholow, S. D., Young, P. S., and Hopkins, T. E. (1996) Striped bass exercise and handling stress in freshwater: physiological responses to recovery environment. Trans. Am. Fish. Soc. 125:308-320.

See also other co-authored publications listed below.

Dr. Christina Swanson has been a post-doctoral researcher in Dr. Cech's laboratory has spent the past five years studying the environmental tolerances, swimming performance, and behavior a Delta fishes, with an emphasis on the biology of delta smelt. She was the managing researcher on three successfully completed state contracts and is currently one of the managing biologists on the Fish Treadmill Project. Recent relevant publications include:

Swanson, C. and Cech, J. J., Jr. (1995) Environmental tolerances and requirements of delta smelt, *Hypomesus transpacificus*. Final Report for California Department of Water Resources, Contracts B-59449 and B-58959. 77 pp.

Swanson, C. Mager, R. C., Doroshov, S. I., and Cech, J. J., Jr. (1996) Use of salts, anesthetics, and polymers to minimize handling and transport mortality in delta smelt. Trans. Am. Fish. Soc. 125:326-329.

Swanson, C., Young, P. S., and Cech, J. J., Jr. (1996) Swimming studies on an estuarine fish: are performance indices the best tool to develop flow management criteria?. Proceedings of the Applied Environmental Physiology of Fishes Symposium, International Congress on the Biology of Fishes, San Francisco State University, July 14-18, 1996. Pp. 83-91.

Swanson, C., Young, P. S., and Cech, J. J., Jr. (1997) Swimming performance and behavior of delta smelt: maximum velocities, endurance, and kinematics in a laminar-flow swimming flume. Final Report for California Department of Water Resources Contract # B-59742. 67 pp.

Swanson, C., P. S. Young, and J. J. Cech, Jr. Swimming performance of delta smelt: maximal performance, and behavioral and kinematic limitations on swimming at submaximal velocities. J. Exp. Biol. 201: 333-345.

Dr. Paciencia S. Young received her doctoral training and is currently a post-doctoral researcher in Dr. Cech's laboratory. She is an expert in the areas of stress and exercise physiology of fishes and has spent the past four years studying the environmental tolerances, swimming performance, and behavior a Delta fishes, with an emphasis on the biology of splittail and delta smelt. She was the managing researcher on two successfully completed state contracts and is currently one of the managing biologists on the Fish Treadmill Project. Recent relevant publications include:

Young, P. S. and Cech, J. J., Jr. (1993) Effects of exercise conditioning on stress responses and recovery in cultured and wild young-of-the-year striped bass (*Morone saxatilis*). Can. J. Fish. Aquat. Sci. 50:2094-2099.

Young, P. S. and Cech, J. J., Jr. (1995) Environmental requirements and tolerances of Sacramento splittail, *Pogonichthys macrolepidotus* (Ayres). Final Report to the Interagency Ecological Studies Program for the San Francisco Bay/Delta. 56 pp.

Young, P. S. and Cech, J. J., Jr (1996) Environmental tolerances and requirements of splittail. Trans. Am. Fish. Soc. 125:664-678.

Engr. Shawn Mayr (participation pending), a civil engineer with the Fish Facilities Section, Environmental Services Office, DWR currently working with our research group on the Fish Treadmill project, will assist and consult with the design, construction, testing and operation of the ADA.

Mr. Ted Frink (participation pending), a biologist with the Fish Facilities Section, Environmental Services Office, DWR, currently working with our research group on the Fish Treadmill project, will assist and consult with us on the QAPP, experimental design, implementation, and data analysis for the ADA experiments.

Mr. Robert Fujimura (participation pending), is a biologist with DFG currently working with our research group on the Fish Treadmill project. He will assist and consult with us on the QAPP, experimental design, implementation, and data analysis for the ADA experiments.

C. Conflicts of Interest

There are no existing or potential conflicts of interest for any of the personnel involved in this project.

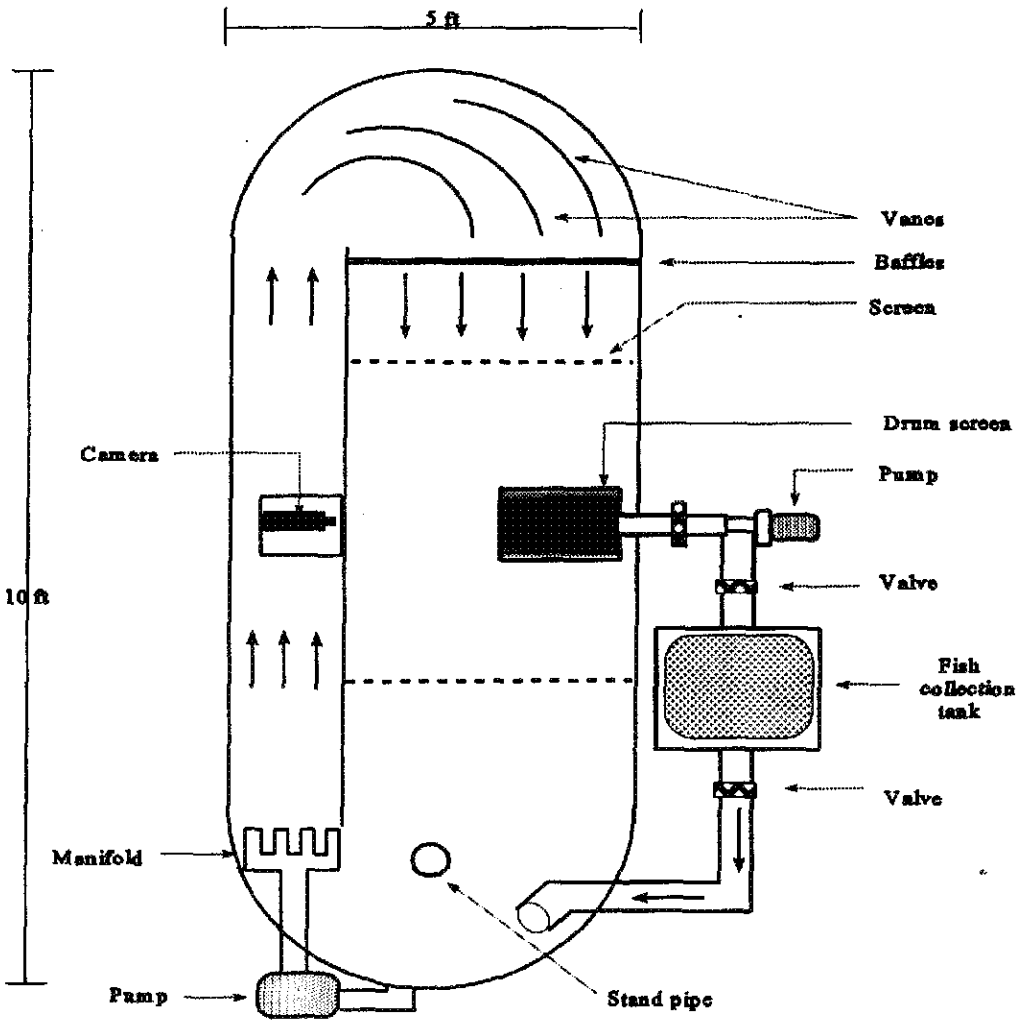

Figure 1. Diagram of the proposed design for agricultural diversion apparatus.

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